

Welcome and Introductions

*Co-Chairs: Elizabeth Dowdeswell, Visiting Professor, University of Toronto; former Executive Director, United Nations Environment Programme
Stuart Smith, Chair, National Round Table on the Environment and the Economy*

Following welcoming remarks by workshop co-chairs Stuart Smith and Elizabeth Dowdeswell, Environment Canada Deputy Minister Alan Nymark told participants how pleased he was that the Initiative for Science and Technology for Sustainability (ISTS) was taking place.

“The matters which you are discussing over the next couple of days are really at the heart of much of the public policy agenda on the future of human beings on this planet,” he said. Future progress will “depend on the advance of our science and technology,” and as a leader in technological development, “it’s most fitting that North America should contribute our own perspective to this global debate.”

While the value of science and technology has been integrated into the North American public policy agenda, Nymark said the concept of sustainable development has been useful in answering questions about the purpose of science. “The Government of Canada has embraced this concept as one of the key bases for decision-making, and as a long-term vision for society, but I must say the implementation over the past 15 years or so has proven to be much more difficult than most of us would have predicted.” This may be because “many of the key tools [for implementation] simply do not exist, or are not sufficiently developed in order to pursue the laudable goals of sustainable development.” The same can be said for decision-making processes and frameworks, including the flow of information and indicators that will help nations measure their progress toward sustainability.

With the World Summit on Sustainable Development just five months away, Nymark suggested that participants focus on the place of science on the agenda for global discussions. “Part of the work you’re involved in will be not only be to get the thinking right on the role of science and technology in human well-being and a better environment, but to become a little bit political and get yourselves on the agenda,” he said. “Leaders are searching for something useful for Johannesburg, and I think the work you’re engaged in over the next couple of days really does deserve to be higher up in the priorities for that meeting.”

Dowdeswell noted that the sustainability science initiative would still have taken place, independent of Johannesburg, but agreed that “sound science is fundamental in finding some of the solutions and responses to the challenges the world community is facing.” The question of implementation is “integral to the kinds of questions we’re going to discuss,” she said, adding that past efforts based on ecosystem science “simply haven’t led to implementable policy. It

hasn't moved the yardsticks along." She said it might be useful for the workshop to explore what science countries are doing, how it's organized, and the impact it's having, especially at the regional and local level.

Dowdeswell and Smith both stressed the need to break down silos and deal with crosscutting issues. At the same time, Smith urged participants to remember that there were three countries at the table, so that not all the squares on the reference matrix would be filled in. He noted that when a meeting like Johannesburg can't look back on a good record of performance and has nothing major on which to agree, delegates agree to study the matter—and if that happens, the ISTS could be a prompt for the nations of the world to study the sustainable development challenge scientifically. He said the key issues are how to fund, organize, co-ordinate and explain the research and development work that must be done; how to support more research that has more effect; how to get research results out into the real world; and how to get private sector funders and participants more involved in research.

The Context: The International Initiative for Science and Technology

Dr. Robert Correll, Senior Research Fellow, Harvard University

Robert Correll traced the ISTS legacy back through a series of international meetings, from the 1980 World Conservation Strategy through a workshop in Friibergh in 2000 that brought representatives of the scientific and development communities together to discuss fundamental questions related to research priorities, institutions, and infrastructure.

The Friibergh workshop identified a series of core questions, including the strong, dynamic interactions between nature and society, the need to look at things over long periods of time, and the need for broader perspectives on the research enterprise. The workshop led to a series of six regional workshops, including this one, designed to address four key issues in different cultural and societal settings. In the North American context, Correll framed the issues as follows:

- The fundamental questions to be addressed from the perspective of the three North American countries;
- Institutional and infrastructure needs;
- How to overcome barriers;
- Areas where nothing is happening, even though the current state of knowledge is adequate to inform action.

He said the workshops to date in other regions of the world generated important insights:

- If issues are framed at the wrong scale, the wrong questions, and therefore the wrong answers result.
- Region-specific science issues matter. They cut across regions, even though the specifics differ.
- Institutional issues are very important, beginning with the recognition that the issue of infrastructure is “profoundly different” in different regions. In Africa, for example, 75% of the follow-up e-mails to regional workshop participants bounced back, not because the addresses were wrong, but because the IT infrastructure was so limited.
- Traditional knowledge is hugely important, from the Arctic to central Africa.
- Issues of resilience and adaptive capacity have come up in every regional workshop.
- The importance of lifestyles, behaviour, and values emerged as a key discussion point in Europe.

Even if the Johannesburg meeting were not taking place, Correll stressed that a community of scholars, practitioners and development people would still be coming together to explore better ways of placing science in the context of the communities where it resides.

Dr. Robert Kates, International Initiative on Science and Technology

ISTS Co-Convener Robert Kates said the World Academies of Science and the U.S. National Academy of Science decided to take a long view of sustainable development, treating 2050 as a horizon that would be meaningful in a scientific context but could also be placed on the scale of two generations of humanity. For a researcher, he said, the realization that your eldest granddaughter will be 70 that year becomes a focal point for the broader goals of meeting human needs, reducing hunger and poverty, and maintaining the planet’s life support systems.

Kates said sustainability science and technology calls for an integrative, regional approach anchored in a concern for the human condition, and takes place at the intersection between environment science and development science. He added that if the Friibergh workshop could be rerun, he would add a focus on specific action needs where science and technology can make a difference.

In the work that has been done since, Kates said, some of the emphasis has been on areas where there is enough knowledge to take action now. A world population projection of nine billion can be brought down to eight billion, by connecting condom distribution programs with schools for girls. Similarly, scientists know how to address declining agricultural production in Africa, how to at least double the efficiency with which the world uses energy and materials, and how important it will be to address rapid urbanization on a global scale. Against this backdrop, the core questions leading to research and action priorities for North America have to do with methods and models, long-term trends, vulnerability in particular places, critical limits and

boundaries, incentive systems at the societal level, monitoring and reporting, and the overall need for Research, Observations, Assessment, and Decision Support (ROADS).

Kates urged participants to consider how these questions would differ if they were needs-based, rather than science-based, and how relevant the questions are for North America. He suggested some regional adaptations for the research questions developed at Friibergh, and stressed the importance of developing collaborative instruments that bring local knowledge together with specialized expertise.

Questions and Discussion

A participant asked if the goals of reducing poverty, improving the human condition, and achieving sustainable development are incompatible. Kates said a group of consultants had explored the simultaneous goals of reducing hunger by half in each of the next two generations and cutting atmospheric carbon down to 450 parts per million. They found that it would be possible to do both, “but it’s going to take a lot of stretch for society to make it happen.”

Another participant acknowledged that the ISTS process was independent of the World Summit, but asked what product the organizers hoped to bring forward to Johannesburg. Correll said the regional dialogues had been asked to generate a reasonably detailed foundation document that indicates what participants have learned, the questions that should be addressed, and a sharply defined list of issues that connect to the political and policy process leading to the Summit. As an example, he cited the question of how to facilitate ROADS-style research in Africa, “where the capacity to do that is just indescribably weak.” The key to success, he said, will be to work with the heads of state that actually create the agenda: “We have to have some interactions with the people who are going to carry that day.”

A participant said a stronger policy role for science and technology will hinge on a better understanding of the border between scientific certainty and uncertainty. For example, he said, “there’s still a school of thought that gets more air time than it ought to” that questions the level of scientific certainty on the human effects of climate change—and at the end of the day, after all the equations are in place, the answer to many questions is still “it depends”. The challenge for science is to find a better way of “gathering the weight of opinion” to be able to suggest appropriate directions to policy-makers.

Community action is the other priority, the participant added, because science and technology will only take us so far. This “groundswell of effort” will require a value-driven change of mindset, he said: “Every time I see a television ad with a four-wheel drive vehicle sitting on top of a mountain, I think to myself how much damage was done just to make the ad, let alone the mindset that encourages people to do that.”

Another group member said Johannesburg could lead to a series of Type 2 agreements, in which constellations of countries establish clear targets, financing and political will to pursue common goals. An event like the World Summit becomes an opportunity for the international community to announce and reinforce that kind of initiative. “It’s a new kind of opportunity emerging,” he said, adding that Canada, Mexico, and the United States might want to put forward a strategic initiative on sustainability science and technology.

“That’s a dramatic process issue going into Johannesburg,” the group member said. “It’s the notion that what a group of countries does to achieve a particular mission is important and worth putting on the world stage, so that you don’t end up negotiating to the lowest common denominator.”

The next speaker said scientists and engineers are on the cusp of an “incredible opportunity” to develop something brand new, by finding the synergies among disciplines that will actually give definition to sustainability science. She also emphasized the practical challenge of conveying scientific knowledge to non-scientists, and especially to key decision-makers in governments and institutions, recalling early icons like Rachel Carson’s *Silent Spring* that “got into peoples’ heads” and galvanized Americans to change their environmental thinking. She added that her own organization was trying to promote a Type 2 deliverable for Johannesburg dealing with materials flow analysis.

A participant said knowledge includes the “technology” required to fix social problems that tend to receive less attention than scientific solutions. In thinking about obstacles and opportunities on the path to 2050, he said, “the salient question that concerns me is equity. This has been touched on briefly, but it doesn’t seem to appear very prominently in the presentations that have been made. One of the major threats to sustainability over the next half century is the enormous level of global inequity,” making it important to ask whether developing countries advocated a regional focus for ISTS as a way of drawing attention to the challenges they face. “You’re presenting us with questions in the context of North American needs, and I wonder if that’s a good thing. Because looked at globally, we don’t have any needs in North America. In fact, we need to get rid of our needs,” the participant said. He urged the group to think about the impact that the United States, in particular, has had on the rest of the world, and to think about the available knowledge that North Americans are not using to advance and develop sustainability science.

A group member called for an integrative approach that links science with other areas of knowledge and abandons the mechanistic thinking that, for example, makes it impossible for politicians to deal with uncertainty. He stressed the need to critique a dominant philosophy that assumes we’re happier and better off if we consume more, and called for caution in relying on the private market as a solution to the sustainability challenge.

Kates and Correll summed up the discussion so far, with Correll highlighting a participant's comment on Type 2 agreements. "We all ought to think more seriously about that," he said. "There's a possibility of carrying a very powerful message that would make the World Summit seem a lot more productive" than many people currently believe possible.

Atmospheric Change

Omar R. Masera, Instituto de Ecologia, UNAM

The current level of emissions worldwide is completely unsustainable—continuing "business as normal" will increase the greenhouse gas levels in the environment and increase global air temperatures, said Omar Masera. Substantial changes need to take place in the way this problem is dealt with. There is also a substantial time lag—the consequences of any action taken today will not be felt for many years to come, and the consequences of doing nothing will affect health for many years to come. Acting now to effect a reduction in emissions will stabilize temperatures in a few centuries, but there will still be residual warming. This clearly presents a problem if a typical timeframe is used, but is also one of the reasons why the problems of climate change are so elusive for many—any visible effect is far off into the future.

The consequences of this problem vary dramatically across regions, something that makes a difference in how the problem is perceived. North America has the highest level of emissions per capita, and is a key player globally. Both the U.S. and Canada have high per capita emission levels, but even Mexico falls within the top ten countries worldwide. The Kyoto Protocol, which the U.S. is not willing to ratify, will only move the solution partway forward: Masera noted that it is still insufficient in relation to what is really needed. Mexico has already ratified the Protocol.

Contrary to the opinion that reducing emissions will be expensive, researchers in Mexico have shown that there are a number of cost-effective options that can take place within the first ratification period that will reduce emissions. Masera said he wanted to build on remarks made earlier in the day and emphasize that a different path is needed. Rather than taking the science and breaking it down into more and more finite areas and sub-groups, a connection needs to be made between basic issues of health, water, and air quality at the local level, and climate change. In conclusion, Masera emphasized the need for a multi-scale analysis at the local, regional, and national levels.

John Stone, Associate Director General, Policy and Corporate Affairs, Environment Canada

Building on Masera's comments, Stone noted that from the time of the Industrial Revolution, humankind has altered the composition of the environment. Carbon dioxide levels, greenhouse gases, NO_x, and "chemicals we didn't even know about 50 years ago" have all increased many

fold in the atmosphere. There are numerous local effects such as smog, increased respiratory problems in populations, and concentrations of aerosols that give rise to local ecosystem damage. Acid rain has negatively impacted forests and lakes. Many remediation efforts are being tackled internationally through efforts such as the Kyoto Protocol, the Montreal accord, and accords in Europe. These are being done independently, with insufficient recognition of the synergy between these accords, and others on biodiversity and certification. Stone commented that this is unfortunate from both a process and mechanistic point of view, as well as from a scientific point of view. These effects compound additional stresses and vulnerabilities such as ecosystems. Many are related to fossil fuel burning, but as well, many chemicals interact in the atmosphere, a situation that compounds and counteracts effects and efforts to reduce them.

Stone said that within IPCC, there was a push on to examine these interconnections and look at the links between climate change and sustainable development, asking what it was in climate change that would have impacts on social development plans. In tackling climate change wisely, other sustainable development goals can be achieved. For example, increasing climate sinks will increase water retention levels and biodiversity. These can be modelled by “scenario” projects. Initially, the drive to write this paper came from developing countries, but many developed countries were skeptical. However, the project did not pass in the end, due (surprisingly to many) to the reticence of developing countries.

Discussion

Prompted by Stuart Smith to discuss the scenario above in terms of a research agenda, Stone replied that this was not a research agenda problem. Masera reiterated that his comments referred to the ineffectiveness of the connectivity between science and the political process. “Every time we have tried to connect sustainable development and climate change, there is not enough support for it. The agenda has been to subdivide and subdivide... We need instead a participatory approach, not a top-down one. We need to connect local needs with the political process.”

A participant from California agreed with Masera’s approach. Commenting on the local concerns about air quality and mass transportation in his area, he noted attempts have been made to connect a number of disciplines ranging from medical schools to the chemical industry to anthropologists in a solution. He proposed that an enabling mechanism is needed, something like a regional workbench—a portal, not a warehouse—that would allow the various disciplines to work together. If each of the stories heard concluded with suggestions for effecting change, if the tools were place-based and partnership based, the solutions in each region would look different. How one enables a research-driven, integrative approach, and develops a place for these views to be kept and guarded is key. The participant suggested that plenty of innovation is taking place along those lines.

Smith summarized that although the science of climate change is well established, the science of its impact is evolving. “Our best bet is to do regional research in interdisciplinary, partnership

way.” The previous speaker agreed, but cautioned that by looking for regional analysis and solutions, he was not proposing to forget the global problem. For example, thousand-mile long plumes of pollutants coming from Asia invade California’s airspace, but regionally, this has a big impact on children and asthma levels. “There are very strong imperatives for regions to work together,” he stressed. “One of our niches might be to build this information integration tool.”

Another participant asked Masera if there is renewed interest in a forest/water link with the current administration. Masera replied that although deforestation is difficult to stop, there has been some recognition given the need to provide an economic incentive to those who maintain the integrity of forests. The “butterfly project” is an example of a program that pays peasants for the economic service provided by their forests. There is also a growing realization in tropical countries that the main role of mountains with forests is to provide water for arid areas.

The recent softwood lumber negotiations are an example of how policy and science are seldom linked, suggested a speaker. Nowhere in the negotiations was the issue of sustainability discussed. Similarly, in the run-up discussions to Rio, some suggested that climate change should be discussed in a more holistic approach—not on its own—only to be told that these complicated issues need to be dealt with in manageable levels rather than all at once. There was a total gulf between the experts who wanted to move the agenda toward integration and scientists who did not.

Progress is often stymied because of a lack of will, not because of a lack of knowledge, suggested another participant. He recalled a paper written in 1974 by Rowland and Molina about CFCs in the atmosphere, a paper ignored and actively discredited within industry and academic circles for 15 years—only the young and those involved in the environmental movement paid much heed to it. For almost two decades nothing happened until others confirmed the hole in the ozone layer, and Rowland and Molina were given the Nobel Prize. Another important issue is the agricultural debt line in developing countries—the massive abandonment of agricultural fields by countries that cannot deal with cheap imports. This presents a “huge opportunity” for scientific study and has a number of impacts that are only just becoming apparent. The first is the massive migration into cities, or to neighbouring countries. The second is the replacement of traditional agriculture by high impact agriculture that contributes negatively to climate change by the increased use of fertilizers, huge energy demands, and fossil fuel use. Hundreds of thousands of hectares are being abandoned each year in Mexico alone. On the plus side, this switch provides an opportunity for reforestation, sequestration, and opens a realm of opportunities yet to be explored. Smith commented that this is not just occurring in the Third World—Canada is now exploring ways of moving marginal lands out of agricultural production. Reforestation will be advanced further if a credit system is adopted.

A speaker highlighted his twenty -year experience linking science and policy within a government environment. Recent polls by Agriculture and AgriFood Canada confirmed that Canadians want safe food that is produced in an ecologically sound way, providing a role for

science. Within five years, “we could visualize a farm plan for food security, like the ISO 9000 approach, along with an environmental farm plan.” Food safety and environmental health are the links between science and policy.

A participant noted that in the design of two major science programs that dealt with the ozone problem in the U.S., a seminal decision was made to engage scientists and chemical manufacturers from the start. This enabled a very rapid response in 1995 that culminated with President George Bush signing a memorandum of agreement—something that happened because of personal contact between President Bush and the president of Dupont. The partnership issue is central to problem solving. Responding to an earlier comment that place-based action is equally important, the speaker referred to another participant’s discussion about a “Type 2” approach. An assessment is underway in the Arctic in which scientists are not only asked to comment on a problem, they are being asked to submit action-based solutions. He said that if place-based science or strategies are valid, so are place-based solutions.

Another participant commented that price and cost must be weighed into any policy options. Many people on this continent have lost their environmental conscience, and if behavioural change is to be effected in the right direction, the mindset will have to change.

Stuart Smith said he was surprised he had not heard more about what was happening in the U.S., which is reportedly developing new technologies as an alternative to ratifying the Kyoto Protocol. Canadians are interested in market pull, and are in favour of ratification, in part because it monetizes carbon.

A participant who chaired the U.S. global change initiative said that the U.S. does not want to talk about this. Established by the previous Bush administration, the U.S. invested \$20 billion over 12 years in global climate change. “As the reality of the climate change issue became clear, the rubber on the road became more difficult,” and funds decreased. The current administration has study groups and has committed to a \$40 million add-on initiative, highly focused on keystone questions. There is also a further \$40 million program on climate change led by the Department of Energy. Two other participants from the United States agreed. The first noted that much time has been spent discussing policy, not the science of climate change. The climate change research initiative was intended to address gaps, not create a whole new program, but that may be shifting as an announcement is expected imminently. Another concurred that energy policy remains one of the most frustrating and important components of this, and should involve the global change community. The U.S. global change research strategy was moving toward being place-based, but did not make it through the change in government.

Stuart Smith asked if this should be a North American initiative taking place on many fronts — researchers could work toward developing cleaner burning coal, better photovoltaic cells, or more cost-effective and safer nuclear power. A participant responded that although many would argue that science understands the problems, he would advocate for a shift toward understanding

how science could be part of the solutions. This shift would also be attractive to those who want to make money from a solution. “Don’t just focus on the science, but let science be the solution.”

Another speaker agreed, commenting that there is a distinctive role for science and technology. This is a departure for the environmental community that too often regards technology as the enemy, and saw the \$20 billion expenditure as a way of putting off action. The launch of fuel cells for cars will sidetrack CAFÉ standards. How to deal with both short-term and long-term needs has always been problematic. He agreed with an earlier speaker who said that integration would take place from below. Over one hundred cities belong to *Cities for Climate Protection*, and next year a number of companies, including Shell, will introduce sustainability indicators. In both these examples, the concerns go far beyond climate change issues.

A participant from the United States noted that it is easy and attractive to talk about strategic initiatives, but argued that tactical moves are now needed. He commented that it is difficult to include these messages in the U.S. dialogue at present, although great headway is being made internationally. Stuart Smith noted that what may actually be chaos and duplicity on the inside may look like brilliant design from the outside! Some think the U.S. is stalling in order to develop new technologies, that once in place, the rest of the world will be pushed to purchase and adopt their innovations.

Commenting on the attempt to push toward a clear exp osition of the barriers with regard to atmospheric change, Smith said that this should be done with all the issues. There was a clear emphasis on a regional focus, and agreement that science and research should shift toward understanding potential solution s, something that would allow the realignment of institutional structures towards that goal. He urged the group to keep the matrix in mind during the afternoon’s discussion.

Air Quality

Rick Van Schoik, Southwest Center for Environmental Research and Policy

Rick Van Schoik said that since he teaches environmental security at two state universities on the U.S.–Mexico border, he can put a place on some of the issues. In this border area there are north-south issues, rich-poor issues, and nature-society issues.

He spoke of three sources that affect air quality:

- Mobile. Changes in truck travel because of the North American Free Trade Agreement (NAFTA) result in congestion at the border, which affects air quality.
- Stationary. Because of the price of land and labour, power plants have been

established in Mexico, where air quality standards differ from those in the U.S.

- Area. Factors such as aridity impact air quality.

In the region in question, the population is connected to quality of life by the economy. Air quality, land use, transportation, energy, water quality, water supply, and ecosystem services all come between population and the economy, and affect the quality of life, so policy means interdependencies. Van Schoik spoke of the opportunities in setting policy. An example from this region is the extraordinary use of water. Another example is agricultural abandonment, in which land is left fallow in order to save water for the cities. There is an up side and a down side to this practice, which is obviously not sustainable.

Victor Shantora, Commission for Environmental Co-operation (CEC) of North America.

Shantora commented that there is an intersecting role for local, regional, national, and tri-national groups. He mentioned that in the recent discussion of restructuring electricity markets, the presidents and prime minister had discussed integrating energy markets. It looks as though that may be necessary in light of such risks as increased mercury emissions in Canada in the absence of an integrated policy, and the establishment of plants near the U.S. border in Alberta. The absence of unified standards risks the creation of pollution havens. The CEC understands that there are pitfalls as well as gains. If individual countries find it hard to do analysis, the CEC can play that role. Shantora reiterated a point made in the morning: that there is an information overload. A context must be found and a decision made whether to aggregate information or keep it separate. Timing is everything. An issue can be in the background for years, before finding an opportune time to bring it forward.

Discussion

A participant commented that Van Schoik had made it clear that air quality is the true integration of human activities—one cannot just fix some sources of air pollution. As a result of the interactions of multiple emissions, the southern and eastern U.S. have high ozone levels, and not just in the urban areas. Therefore, the solution must be the result of an integrated effort across the whole region. The question is whether or not the knowledge and institutions are available to find these solutions across the whole area. Are the tools available in usable form?

Another participant spoke of grants to local governments under the *Environmental Protection Act* that allowed the governments to decide what the problem was and form partnerships to monitor and deliver systems to the public. She mentioned an automobile emissions program at the border in El Paso as an example, and suggested these small projects could be used as pilots. However President Bush has scrapped the program.

With regard to tools, a participant commented that although bits and pieces of tools are now available, there is a need for integration and the window of opportunity is closing. There are

grants programs for Web-based delivery of information. There is a paradigm shift underway from just producing bigger computers to learning how to enable integrity of distributed data and how to deliver science to all (scientists, government, and public). This question should be discussed at this meeting.

A speaker commented that iteration must happen. Scientists and decision-makers know that links or interdependencies exist, but the recognition may not be there at the institutional level.

A participant said that he had heard one scientist say he had no time for “Web stuff”. This kind of comment identifies a need. Perhaps there is a role for data and information brokers, to make the Web information more accessible.

Another participant summed up the last two points by saying that scientists have pieces of the air quality puzzle. Progress is being made toward a discussion of air quality in the three-country context, at the Council of Ministers in June.

Returning to the point about delivering science to all, a participant pointed out that poor people do not have access to the Web. She said that knowledge may bring change, and gave two examples:

- ozone levels are now given in weather reports
- asthmatic children in the poor community of Roxbury in Boston were given beepers to warn them when the air quality deteriorated to the danger point.

This kind of thing could be done globally. Nanotechnology could allow everyone to have a small sensor in order to know the quality of the air. It would be inexpensive and could produce change.

A speaker noted that change comes with new information and new experiences, like the image of everyone in Tokyo wearing masks. It is important not to bore people in Canada with the problems experienced at the U.S.-Mexico border, but it is still important to publicize forcing events such as the three-day shutdowns of Mexico City and Santiago because of poor air, and the discovery of North African grasshoppers in the United Kingdom. Events like these should be reported powerfully.

A participant lamented that the examples were all of critical situations so that action must be remedial. He suggested trying to think of preventive situations. Another participant agreed and pointed out that funding often only occurs when a problem can be proven. Thinking about sustainability takes a different form, that of planning for the future, not fixing past problems.

Smith pointed out that only religion pursues long-term intangibles before short-term tangibles. Science should work towards making intangibles seem tangible, like the canary in the mine metaphor. Exhortations will not help.

Another aspect of this, said a participant, is to look for win-win situations that abound.

Dowdeswell asked how the space program has been so successful, if the pursuit of long-term intangibles is not a feature of science. “Sputnik” was the immediate answer.

However, another participant commented that even when people know a problem is coming, they often fail to act. There are institutional barriers preventing us from learning from past disasters. Hurricane Mitch had a devastating effect on people living where it was unsafe—11,000 people died and economies were set back. The U.S. is rebuilding after Hurricane Mitch but no one is looking at other countries where people are just as vulnerable. A slightly more positive example of learning from the past is with El Niño. The knowledge was there in the early 1990s and became very visible in 1997/8. However two years later it is hard to keep the momentum. How can governments incorporate this kind of knowledge over the long term?

The science of the effect of air quality on a vulnerable population is not done, said a participant. The reason that manganese was not banned in Canadian gasoline under NAFTA is that it has not been proven harmful. This kind of study could be done in North America.

With regard to air pollution from automobiles, asked another participant, is it possible to make a contribution from another approach? The typical approach is to encourage the use of smaller cars and a reduction in automobile usage. We should be thinking about an alternative to cars, imagining cities with other ways of moving people. Similarly the food delivery system should be restructured to support local production. In the U.S., the average distance food travels from producer to consumer is 900 kilometres.

With regard to studying the effects of air quality on vulnerable groups, a speaker cautioned that the more sophisticated the picture, the more murky it becomes. There are Canadian and American studies on the health outcomes of air quality. Health is likely the most important forcing event. In Australia the increase in skin cancer led to changes in health programs. Children are now not allowed outside to play unless they have brought a hat to school.

Returning to Dowdeswell’s question, a participant said that the Sputnik model of competition would be a good thing in sustainability science. The money is available for nanotechnology because of global competition. Is there a parallel in sustainable science, such as fuel cells?

A participant commented that the rewards system for scientists—academic progression, publication in academic journals—does not exist for sustainable development science. For example, it wasn’t working when people recently died from drinking municipal water in Ontario. Grants were used to enhance the municipal budget rather than produce clean water.

Dowdeswell changed the subject to the issue of indicators and said it was time to hear from Ole Olsen, as he had not yet had an opportunity to speak.

Ole Olsen, Former Swedish Prime Minister; former Swedish Minister of Foreign Affairs; former Ambassador to Canada; and former Ambassador to Italy

Ole Olsen thanked Dowdeswell for the invitation and said he was struck by the degree of wisdom around the table. He equated indicators to beepers, saying that the signal helps policy makers know what to do. There are economic indicators on everything, to let policy makers know if the economy is in good health and whether or not any corrections are necessary. However, this is not the case with the environment. Sustainable development is a doctrine of limits—it teaches us to see that the ecology sets the limits.

There are people who say it is important not to sign the Kyoto Protocol. However the economic cost they quote is actually a reason for signing. Economic gains for not signing will be at the expense of sustainable development.

It is possible to create indicators, not necessarily in dollar terms. The point is that they would be something on which the government could report at certain intervals. Olsen spoke briefly about the project in which he is involved, to establish forest capital measures that value forest resources beyond timber.

Smith reported that the National Round Table on the Environment and the Economy (NRTEE) will produce a few core indicators that the ordinary citizen can understand, as well as a system of accounts—a total saving index. These will be indicators, not statistics. They must not be open to interpretation about whether they are good or bad. They will not be quality of life indicators and there will no aggregating factors, no weighting.

A participant said that the Council of Ministers asked the CEC to look into the development of North American indicators. They will focus on the Organization for Economic Co-operation and Development (OECD) indicators and find a North American slant.

Water quality

Exequiel Ezcurra, National Institute of Ecology

Modifying a presentation he gave to the Mexican government for the UN's "International Day of Water" Ezcurra demonstrated that there is an uneven distribution of water resources across North America in space and in time. He also illustrated the importance of forests to water, and argued that many governments are subsidizing the inefficient use of water.

Mexico is influenced both by the trade winds (tropical winds) that hit the Caribbean and the westerlies (temperate) that hit the west coast. As the latter winds are temperate and affected by

the hotter water (in comparison to the temperature of the continent), winter rains are generated. The tropical trade winds in the Caribbean generate seasonal monsoons. Between the two weather and current systems is a desert. Ezcurra noted that Mexico talks about a “drought” in this region when in fact it’s a desert! It may cease to be dry for short periods of time such as under El Niño conditions. In Mexico when the sea collapses under these conditions the land blooms with abundant rainfall—the two systems are in discordant harmony.

Water resources are heterogeneous in space as well as in time, said Ezcurra. Mountainous and forested areas in North America effectively capture water and control runoff. Their function is far more important than any money their forest resource could generate. Forests are irreplaceable as water regulators.

Ezcurra used a mathematical equation to show the amount of water needed to produce one kilogram of maize, alfalfa, and beef. Much of the water needed for agriculture has to be pumped from deep aquifers, and this requires significant energy expenditures. For example, 4.2 litres of gasoline are required to pump the water necessary (31 m³) to raise 1 kg of beef. “It is so costly that the government is subsidizing the production of water,” said Ezcurra. Desalination is even worse. Eight litres of gasoline are required to produce 1 kg of beef using seawater, a feat so prohibitive that no one has attempted it.

There is also a problem with freshwater use in cities. Most cities use water from external sources (basins) that require the water to be elevated more than 1,000 metres. Ezcurra asked how much it costs to supply freshwater to Mexico City and was told that no one knew. He then calculated that it would require the constant average power of one or two nuclear plants working fulltime to supply water to Mexico City at a cost of ten times what consumers pay. This works out to a federal subsidy of 90% to supply the water. California is another example where the water comes from the Colorado Valley and has to be elevated. Ezcurra commented that the cost of supplying water in dry environments requires an incredible subsidy. Water is heterogeneous in space, but moving it is incredibly expensive, “and we are reaching the point where it’s not cost effective.”

Ezcurra used another slide of an area where freshwater was diverted away from flowing into the sea to show how 300 square kilometres of wetlands were lost when the river was dammed. Mexico ranks seventh in the globe in terms of the number of irrigation projects. It has already exhausted most of its surface water sources and a large proportion of its aquifers are severely depleted. Furthermore, severe water pollution from industry and agriculture is exacerbating the problem in many areas. “Clearly, cheap fresh water has reached its limit in Mexico,” concluded Ezcurra. “We need a new approach and thought.”

Discussion:

A participant asked about cost estimates for providing clean water, and was told it was approximately \$1.50 to \$2 (US) per cubic metre. The costs are prohibitive for seawater

desalination.

Commenting on the “wonderful presentation” another participant asked about linking science with policy and planning. Ezcurra replied that although many municipal governments in Mexico are concerned with seawater, his recommendation was to stay clear of desalination projects. However, another more cost-effective recommendation was to use inverse osmosis to treat water. He suggested that governments were going to have to look for ways of treating water numerous times so it could be reused many times over, rather than looking for new sources of water.

A participant highlighted the underlying economics of irrigation, saying that irrigated rice was “the goofiest thing imaginable.” He called on governments to stop using tax dollars for economic lunacy, such as financing non-sustainable activities. Another speaker noted that 85% of fresh water in the U.S. is used for agriculture, and asked about a multi-source policy, in which some of the water would be used for drinking, another source for cooking, and yet another for agriculture. Ezcurra agreed there is a concern about fresh water quality, and said that much of the water used for agriculture in Mexico would not be used for personal consumption.

Asked if it would help with water shortages worldwide if, for example, people in Stockholm reduced their water use, Ezcurra said it would not. “We have lost the fact that much of the south is a desert. We have lost the culture of living in a desert. People in L.A. want lawns and golf courses—in a desert!” he said, adding that it’s possible to have a garden without a lawn. “We have acquired the cultural belief that we can live using the same water as an Englishman. We need to change. There are culturally appropriate crops and many other things that can be done.”

There are three problems related to water in the tropical southeast part of Mexico. The first, related to the oil industry, is pollution. A plume of contamination can be seen from space. The second is erosion in the mountains due to deforestation. The final concern is specific to the Yucatan Peninsula, which geologically is a poor filter. Underwater pollution from brownwater travels for miles and contributes to many health problems.

A participant asked Ezcurra how science and technology could help a limited resource become sustainable. Ezcurra said that his recommendation would be to kill the tariffs and make consumers pay. One participant commented that the political will to do so is lacking, while another noted that there are many opportunities to use water more efficiently in areas of scarcity, but no corresponding pricing incentives. In California, the legal and social side of the issue—legal rights and historical allocations—have inhibited any attempts to price water fairly. The first participant noted that more efficient technologies have been developed, but cost money to put in place, while the second noted that as many things cost producers more, it should be up to consumers to assume more of the costs. Places that have decided to try and allocate water resources more fairly have discovered that there are no institutions in place for deciding on allocation, or for shouldering blame if a mistake is made. “That is something we haven’t learned to deal with in California,” she said. Yet another commented that one of the challenges of

sustainability science is to ensure that the right people are at the table as a water law is developed.

Science can help decide the degree to which water is renewable, suggested a participant. In some instances a drop of water can be reused numerous times, although not in climates with a tremendous amount of evaporation. Another noted that industry will modify its behaviour when supply is threatened. Industry will only move ahead of the curve for either competitive reasons or in order to save money. Science can help by disseminating the knowledge that is “out there” and showing the interrelationships that exist.

A participant from Canada noted that only 15% of water used for personal consumption, and suggested that science should address the management, treatment, and reuse of water. Pharmaceuticals are entering the water supply with increasing frequency, both from domestic use and from agricultural antibiotics. An American participant said that water consumption is already on a declining curve—U.S. agriculture is past the point where it uses increasing amounts of water per unit of produce. He suggested that core questions #5 could be rephrased to come up with a different answer. A major scientific effort would be to study incentive issues and their effect.

Two examples of water policy already exist in Canada, noted Dowdeswell—the prairie provinces have a water board that has dealt with water allocation for over five decades, and the Great Lakes area has a water board. “Water will be the issue that emerges in Johannesburg, and I’m concerned we will coalesce in a non-productive way,” she said, adding that it is important to think through what contribution science and technology can make. “We may be called to answer this because of the political agenda. I’m not sure an international convention is the answer.”

Ezcurra noted this situation was not unique to water—subsidies to oil and coal, for example, are endemic. The interface between science and policy is under discussion. Commenting that large companies have big lobbies, a participant agreed that this debate was common to many issues, and said that although science can prepare for non-sustainability, trade issues also play a part. It is important for science to establish facts, generate solutions, and include economics. He noted that market failure is pervasive worldwide. For example, rice is being eaten as a staple in Peru when it should be potatoes. The cost of buying the rice is nowhere near the real cost of producing it. He suggested that a research agenda should focus on improving the effectiveness of markets, and on developing alternatives such as the use of indigenous systems. “We can’t have lawns and gardens without some costs,” he said, stressing the need to create habitats and focus on ecological restoration. Science education is also important.

The proper institutional framework has to be constructed, one that differentiates water quality, proposed a participant. Consumers are not only willing to pay a high price for high-quality water, they are also willing to pay for long-term water conservation. Constructing property rights collectively allows local control over supply and markets. It is not enough to develop markets

though—something has to be done at the supply side to build up institutional capacity in order to ensure an adequate political response. The participant suggested that sustainable science should focus on this opportunity to reconstruct the environment, something very different from the science of crisis.

Observing that business advocates often claim a science-based rationale for their actions, a speaker cautioned that policy makers must ensure a privatized water system will reach the vulnerable. Riparian uses are not in the realm of arguments of those in the business community. “When we reinvent, let’s worry about the legitimacy about what we’re inventing,” he said.

Science and technology policy can enable a regional approach to water management, suggested another participant. Noting that there are no data collection protocols in the San Diego area, which has 11 watersheds, he said that science and technology could be prescriptive by enabling knowledge-based integration such as through a GIS mapping system.

Yet another participant commented on a study undertaken in New York State that determined it would be more cost effective to protect the Hudson River than it would be to build a new water treatment plant. A considerable amount of water is wasted through distribution systems, yet there are weak incentives to invest in infrastructure. In order to enforce conservation, water metering is needed, something that’s very expensive. The participant remarked that although many think market economics are great, there is no proof that markets lead to sustainability. In practice, there are very strong vested interests in markets, as evidenced by the gun lobby. Finally, there is the cultural aspect that should not be overlooked—many believe that free water is an entitlement.

“We haven’t talked about what social scientists apart from economists can bring to bear to this,” observed a participant. Social and anthropologic questions have to be asked. “These are experiments—we don’t know what does and does not work.” Some water-based management systems work well, while others do not. She suggested that there is “a huge research agenda for social scientists too”, particularly on the psychology of making hard decisions.

Stuart Smith concluded that he had heard a fascinating discussion on water, but apart from the science of metering, not “a whole lot of science.” He agreed that the issue is complex, but said he was not sure if it was a science and technology issue—it might be a political problem, or a social science one instead.

March 26, 2002

Biodiversity and Ecosystem Function

Pamela Matson, Stanford University

Matson began by summarizing the issues surrounding biodiversity and ecosystem function, and the ways in which work is moving forward in the area. It is a huge topic, she said, that is often separated by differences in the surrounding legislation and different research.

The two main issues in the biodiversity realm are the rapid rate that species are being lost, and the homogenization of species.

There are many ways of defining the ecosystem function realm, but the provision of goods and services is the central issue. Examples of goods are food, fisheries, and fibres obtained from forestry. Many good and services, such as water purification and flood control, are threatened by human activities producing:

- Primary changes include changes in land use and deforestation, and effects of agricultural intensification, urbanization, and reforestation
- Atmospheric changes, such as elevation of carbon dioxide levels
- Climate change
- Industrial waste

Matson listed a number of solutions, defining them as anything that reduces the above effects:

- Monitoring the state of the ecosystem and the changes. The impediment is the lack of knowledge.
- Sustainable management. Matson listed fisheries, agriculture, forests, and watersheds, and gave a number of examples of developmental approaches for sustainable agriculture, her subject of specialty.
- Restoration
- Protection. Matson mentioned two different dimensions of protection: laws that protect species, and integrated conservation and development programs around the world.
- Valuing ecosystems. Matson gave two examples: the choice faced by New Yorkers over restoration or conservation, and the payments made to Costa Rican farmers for not cutting primary forest or reforestation of pasture land.

Matson ended her presentation by speaking of her own experience in the Yaqui Valley in Mexico. She learned that ecosystems are difficult to handle on their own because of links. Agriculture cannot be examined by itself. Other areas such as the Sea of Cortez and the Sierra Madres, and other issues such as globalization, urbanization, and climate change affect and are affected by agriculture. No one can manage for conservation without thinking regionally. "A more fully integrated approach is required," she said, "which we do not know how to do at all."

Discussion

In response to a question about corridors and buffer zones to protect species in the wilderness, Matson said that there is science in the approach. Attempts are now being made to link zones so

that they are not islands. More work should be done on this. For some species the agricultural landscape provides enough of a corridor between areas.

In response to another question, Matson said she does not use the term “ecosystem health” because its meaning is not clear, although it is an effective communications term.

Replying to another query, Matson said that the property rights and management issues with regard to coastal fisheries are huge, and acknowledged that aquaculture is emerging as another critical player. Ocean fisheries are under the greatest stress. Costa Rica is a leader in intellectual and bio-property agreements.

A participant elaborated that in many countries, patents protect intellectual knowledge. However, much of the knowledge is traditional, which makes it hard to patent. Brazil has closed its borders to bio prospecting. Mexico’s position is that any patent application should have clear and explicit disclosure of the previous state of the art, to show that value is added; patents should show legal provenance; and there should be an equal sharing of benefits.

Further comments on patenting of intellectual knowledge and bio prospecting included:

- Countries that close their borders might be bypassed and therefore marginalized.
- National patent systems are not designed to protect intellectual property.
- The process has been reversed in Europe.
- Many developing countries do not have the scientific knowledge to determine value added.
- The issue is about protecting the rights of industry, not to honour patent rights.
- The notion that there is value added is not proven.
- There may be a research agenda underpinning this.

A participant described the research program at Agriculture Canada that is divided into themes. For example Environmental Health is divided into soil, water, air and biodiversity, each with a senior scientist in charge. Strategic overviews have been drafted, which are summaries of where the research is at, to provide future direction for research.

Turning to restoration, a speaker commented on how little is known and what a variance there is in the rates of recovery. He contrasted the return of the seal population in California to the much longer time needed for a cactus population to recover. He also likened the promise to restore to a religious confession. A company that agrees to plant seedlings might feel blessed, but who will care for the area for the next 800 years?

Matson agreed that more science is required, and definitions must be made for a range of terms like “restore”.

A participant commented that, for the column in the matrix “Adjusting the S&T Agenda,” a point which is beyond identifying new research areas is the idea of diffusing the knowledge, both within the scientific community and also to the policy makers, educational system, and the communities where research is happening.

Another participant commented that there is a potential science agenda in genetic engineering (which Matson’s presentation had mentioned). The marketing of genetic engineering is visible, but research into the potential negative side is not.

Another challenge, commented one of the speakers, is that there is no organizing model for looking at biodiversity and ecosystem function, as there is in other areas. Since this has eluded scientists, they have dropped down to 15 to 20 worthwhile subject needs. An organizing model would allow us to see the results of the problems. He mentioned the work of Buzz Hollings and asked if it is well accepted. Matson responded that Hollings’ work is well accepted—a group is attempting to bring ecosystem resilience into decision-making. It is a new area trying to link the vulnerability of natural ecosystems with the human environment. In the area of natural capital a lot of research is going into the valuing of ecosystem services. So, while there are concepts underlying a lot of the components that help organize it, there is not just one concept. Sustainable management, for example, is huge.

Asked about the link between biodiversity and ecosystem function, Matson said that it is a hot topic. The research is not yet far enough along.

A participant said that he has the impression that the research community is focused on systems in situ. He went on to speak of migration corridors, and pointed out that species migrate at different rates. So a slow corridor would really have to be a place of residence. Matson agreed, saying that since ecosystems do not move but species do, ecologists are working on the issue through models, not just corridors. It is an area of research already under way.

A participant said that he would prefer to add genetically modified organisms to the list of research topics before bio prospecting.

The research topic of capacity building was suggested. It could be that there is political will to do research but no one to do it.

Dowdeswell commented that the morning’s discussion had a different character than the previous day’s. She asked participants what they thought was different about the morning’s subject. Responses were as follows:

- With changes happening 100 to 1,000 times faster, biodiversity and ecosystem function is the most pressing issue.
- Solutions will take a multi-disciplinary approach—this will complicate the research agenda.

- We do not know how to value ecological goods and services.
- It is a relatively immature field.
- The policy agenda is not clear.
- The application of the science to the policy areas will be laden with value systems.
- Focus has been on natural ecosystems, but it must be recognized that many are modified. There must be a recognition of research into sustainability of modified ecosystems to provide goods and services.
- The subject is not on the agenda because it cannot be understood and therefore cannot be supported. In the absence of an organizing model allowing us to see it in a comprehensive way, progress will not be made. Another issue is communication.
- There are obstacles of jurisdiction. For example, in San Diego—a hot spot for loss of biodiversity—is near an international border. Also, there is a disconnect between marine and land based science. Connection of the two should be on the research agenda.

A participant commented that there is a tendency to separate preservation/conservation out and assume that other areas are managed. However most systems are multipurpose and should be researched as such. Similarly, local knowledge must be integrated with modern. Natural resource management systems should be designed and assessed on several attributes, rather than one, so that the different dimensions of the area can be taken into account.

Dowdeswell asked participants to consider the following question over coffee: Do the questions discussed this morning mean that the political and institutional arrangement should be modified? In other words, should we be suggesting a course correction?

Human Health and the Environment

John Eyles, McMaster University

Remarking that very little heard thus far had been central to his area of expertise—human induced change and the modified environment—John Eyles said that he would be discussing the ramifications of what happens when that modified environment “bites back” and hurts humans. Despite the extremely complex relationship between human health and the environment, Eyles said he would question whether or not it should be included in sustainability science.

There are two approaches to studying the relationship between the environment and human health. The first uses a broad base view to highlight determinants that may have an impact on human health. Determinants are divided into categories as follows:

- Physical determinants, such as temperature, housing, noise, and UV radiation. There is a considerable body of knowledge about their impacts on human health.
- Biological determinants include disease vectors and reservoirs (rodents, insects, etc.—

these are fairly well known); viruses and micro-organisms (there is controversy about the role of viruses in disease like cancer); and biomedical waste (“We don’t have a handle on this at all.”)

- Chemical determinants include agrochemical waste, heavy metals, atmospheric pollutants, dust, and pharmaceutical waste among others. More is known about the first four listed, while very little is known about pharmaceutical waste—“We don’t know how many get flushed into the water system,” said Eyles.
- Socio-cultural determinants include technology, employment, etc. There is a strong gradient between low income and poor health.

The second approach consists of “drilling down to flesh out the science,”—to see what’s what for evidence-based policy. Eyles used the example of air quality to illustrate how this is possible. The United Kingdom has data on air quality and respiratory disease, and was able to conclude that adverse air quality contributes to lung cancer. It’s the science of trying to map out the plausibility of connection. If the elevated risk of mortality from adverse air quality is 3%, this translates into serious numbers of those affected, and shows the need for policy to redress it. A lack of co-ordination between the federal and provincial governments contributes to the difficulty of creating effective policies.

Eyles suggested there were in fact several reasons for including human health in sustainability science. First, human health can be used as a diagnostic tool and aid in establishing research priorities and action items within a policy context—in other words, it can help to set the agenda. Next, it should be included in order to improve health and the quality of life. However, this leads to several questions: Do sustainable practices improve health? Do unsustainable practices always cause health to degenerate? For example, a reduction in predators has led to an explosion in the deer population, and therefore ticks. “The relationship is extremely hard to work out,” conceded Eyles. It can depend on what is included in the relationship.

Traditional hazards relate to poverty—inadequate sanitation, no access to clean water, poor air quality from indoor cooking—and can be found in most Third World countries and many First Nations communities. Other hazards include diseases such as HIV, TB, malaria, and measles. “For me, it’s both a sustainability issue and an equity issue,” said Eyles. “We know the solutions. If we see these environmental hazards as important, what are the right interventions? We should think about an environmental investment.” There are also modern hazards such as water pollution, air pollution, climate change, ozone depletion, and transboundary pollution. The biggest one of all has been cancer. Health effects are moving on to psychosocial impacts, which raise questions of whether or not they are real diseases, like stress. Eyles related an Italian study that followed citizens after a dioxin release in their community. The increased dioxin levels should have translated into increased cancer rates, but instead showed an increase in cardiovascular disease due to increased stress. Its relationship is conjectural but seems to be plausible. These modern hazards are found all over the world—the developing world is catching up. Eyles proposed that the focus of scientific study should be on city regions. “This is a sustainability

issue and an equity issue,” he said. “The distribution is never equitable.”

The challenges are present at the substantive, technological, and theoretical levels. A substantive challenge is to determine the right intervention—should it be clinical or environmental? Eyles suggested the best ones deal with the health of the population, but noted that this has not happened yet in North America. The next challenge is to identify the target, choose the most salient course, and stay that course. The success (or failure) of the endeavour has to be measured, and Eyles advocated the use of health indicators as the right route to take. The United Nations, WHO, World Bank, and municipalities have each produced indicators, so the next challenge will be to standardize them. Once again, when the indicators have been chosen, it will be important to stay the course. The last substantive issue is to learn from others. Eyles said: “We always want to reinvent the wheel, but many Public Health units have done lots of work. This is about information exchange.” That exchange could be Web-based.

Technological challenges include defining “health” as the topic is unwieldy. A second challenge involves data—there is seldom enough information at the right scale, so proxies are often used. Despite the fact that there are chlorination-related diseases, there is very little data about them because the kinds of things scientists are trying to measure are not available. Outcomes can be identified, but there could be numerous causes related to them. Conversely, once an exposure is identified, it could have many outcomes. Thresholds are also another challenge—when it comes to exposure, is there a safe dose? The threshold level varies from substance to substance, so Eyles predicted, “We will move to non-thresholds for everything.” There can be problems with false negative and false positive results, and in order to meet those challenges specific methods such as spatial time-series analysis have to be incorporated.

Regarding theoretical challenges, Eyles urged that principles should be related to the research effort, and in particular, the precautionary principle should be used. Population level impacts should be recognized as being significant. “There also has to be some measure of equity—it’s a slippery, horrible beast—but it needs to be there,” said Eyles. “Equity can help set goals and targets.”

Finally, said Eyles, the pace of change in any policy is slow, and the window for opportunity might well be lost already. “We need integrated studies at the regional level,” he concluded. “They bring people together as a motivator. We need a reason to contextualize the issue.”

Discussion

Dowdeswell reported that the Americans had just held a meeting of Ministers of the Environment on human health, and the issue of the environment and human health will be addressed at the upcoming G8 meeting. “There will be some coalescing around this, and this may be on the agenda for Johannesburg,” she said.

A participant commended Eyles for his “excellent presentation” but said he could not understand why Eyles suggested his topic stood apart from others’. The first set of slides shown at this meeting all matched Eyles’ conclusions. Eyles reiterated that he had not heard much of the human and social side of the problem, but had heard about “civicness” and cohesion.

The science of economics is baseline dependent, while there is little hard science in the study of economic impact, said a participant. Some argue that people relate to their environment through human health, but that relationship has not been exploited from the social point of view. Eyles commented that most people are closer to their pocket books than they are to the environment. Economists have an important role to play in examining the impact of health on, for example, life expectancy.

Another speaker noted that indoor air pollution, affecting primarily women and children, exacts a “huge cost” in respiratory disease”. The other important theme is the role of health and access to health services, such as family planning services. In Singapore, the first child is provided with free education and a variety of services; parents must incur some costs for the second child, while the third or any subsequent children are denied access to education. The speaker said it’s important to project impacts over large spans of time, pointing to the success of predicting a cholera epidemic in India because of El Niño. Eyles concurred that indoor air quality is an enormous issue because so much time is spent indoors. However, he said that a larger issue is migration, with its implications for health, such as, what happens to the immune system when people are intermixed.

Stuart Smith agreed that this agenda has relevance to the developing world, but urged participants to discuss its relevance to North America. Health Canada has a backlog of 25,000 chemicals that have not been tested. “We are just beginning to test the effect of certain chemicals on the endocrine system, but rarely have we tested for effects on the nervous and immune systems,” he said. The growth in asthma and ADD has led to a new concern among North Americans. “We might want to promote an agenda for further testing of chemicals, not just for carcinogenics, but for their effects on other systems.” He used the example of aspartame as an illustration. Aspartame has a huge effect on the mood of vulnerable populations, but the problem is that no one has pinpointed those vulnerable populations. Another problem is that only one chemical has been tested as a time, while the total load and interactive effects are virtually unknown. Smith said there was “not a chance” that industry would pay for that testing, but several countries together could, and he proposed that its inclusion be considered for a North American research agenda.

Eyles commented that transboundary pollution, POPs, and total load are very important to the Arctic, and should be on a North American agenda. A participant said there has been a groundswell of interest in the U.S. during the past six to eight months in integrating health and the environment.

“Taking on 25,000 chemicals is one hell of a challenge,” said another participant, adding that companies that manufacture those chemicals should undertake some of the responsibility for testing them. A possible linkage could be between medical waste and POPs. Waste management and incineration are also problematic. Rather than just looking at dioxins, there could be technological advances made on waste management, particularly for medical waste.

Using San Diego as an example, a participant described how a national institute funded 17 superfund programs to look at environmental toxins from many perspectives, including faculties of chemistry, pharmacology, and biology, among others. “The gulf is impossible to bridge,” he reported, noting that different disciplines operate using different scenarios. “The best we can do is to provide context—a brokering role.” Eyles said that it is the role of the scientists to undertake this knowledge translation function. Smith said he was all for knowledge translation, but not for knowledge broadcast.

Another participant remarked that Eyles has almost provided the chapter headings that organizers were trying to put on this research question for North America—an IPCC for the environment and health. He asked Eyles to drill down on the distinction between the value attached to population and personal health—that “fork in the road.” Eyles replied that the battle had not yet been won. People understand that there is a limited amount of dollars to invest, and the “biggest bang for the buck” will come from an issue that covers 20 people instead of one. “Air quality affects potentially all of us,” he said, so using less sulphurous fuel would benefit many. However, if money is put into an environmental investment, and someone’s father can’t get dialysis, it becomes difficult to convince people of the greater good. Asked if technology would not help to bridge that schism, Eyles responded that that was why he was in favour of Environment Canada taking on the health agenda. It’s an approach that doesn’t pit one group against another, and promote the substitution of funding for health with funding for education—it acknowledges the connection between them.

Human health and the environment relate to all the other issues, commented a speaker. It has some of the integrative qualities this research agenda needs. He suggested that the group should not be looking just at climate change, or heavy metals concentrations. “This issue permeates all other issues—it’s one of the seminal issues—and should be one the table.” Dowdeswell said that this should take place on a broadly regional approach, rather than a global one, for example in the Arctic. Another participant urged this notion be carried even further, and articulated as an emergent property, an improvement of social capital.

The IPCC’s assessments are helpful in informing governments and facilitating negotiations of international regimes or tools. However, cautioned a participant, one must be clear whether a scientific assessment or a policy assessment is needed. To date, the IPCC has produced scientific assessments. The second problem is the scope of the issue that involves chemical, biological, physical, and socio-economic determinants. Finally, the large cadre of health and environmental experts presents a problem. When experts from different disciplines come together they don’t

speak the same language. Those involved in the climate change issue faced a hurdle when they tried to tackle mitigation measures, and undertake an interdisciplinary assessment. Asked if he was suggesting this issue be left behind, the participant said he was unsure, but cautioned that the process must be thought through ahead of time. Eyles agreed that boundaries would have to be set around the task, and said that it's for practical and time reasons that a decision is often made to exclude socio-cultural determinants and concentrate on bio-chemical one first. Dowdeswell said that the lesson of IPCC was to give those involved a two-year head start in order to learn the common language.

Guest Speaker

Honourable Maurizio Bevilacqua, Secretary of State for Science and Technology.

- Bevilacqua thanked those present for the opportunity of meeting with them and listening to the proceedings. Commenting that they should take stock of the great improvements that have been made, Bevilacqua said he was struck by the debate on an American versus global perspective. "It's important to give a North American perspective," he urged. "Many issues need to be addressed, and the rest of the world needs to know about them, while outlining that we understand the global perspective." Bevilacqua stressed the importance of sharing knowledge, pointing out that the private sector has learned that keeping information to itself is not the way to go.

- The answers to some of the questions are already out there, but how to disseminate this information is of fundamental concern. "What you are doing today is no different from a campaign, and this is no different from a war room," said Bevilacqua, adding that many valid points of view were being expressed. The intergenerational view needs to be considered by politicians—what will be left for their children and their children's' children. At the end of the day, Bevilacqua said that the driving issue and force will be "that we want to leave the world a better place for our children. It's about the future. We need to take stock of what has been done and celebrate it."

Taking Stock: What have we learned?

Elizabeth Dowdeswell asked participants to comment on key messages for North America—what they found to be a burning urgency. She especially hoped participants would look at barriers that need to be torn down or modified in order to make progress.

- Barbara Kant agreed with the need to look at problem solutions along with problem

identification. The methods and models used will depend upon the ultimate goal of the exercise. Prevention is needed along with solutions to reverse long-term trends. “There are no social behavioural scientists around this table, and we need to look at human behavioural aspects,” she said. It is difficult for humans to protecting ecosystems because they come from an anthropocentric background. They need to be less so, and put themselves in the place of organisms. This group should not neglect the engineering aspects of the issue, and Kant said that calling it “science and technology” diminishes the engineering aspects. “A discussion on earth systems and engineering is both scary and heartening,” she said. “We have done all this engineering on the earth with no purpose in mind—we have built cities, changed waterways, built roads and dams, etc. through our engineering. Maybe we can engineer for the good now” and work on carbon sequestration, de-engineering dams, and changing waterways back to their original courses. Finally, she urged participants to consider this issue on a big (global) to small (nano) scale.

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- Raúl García Barrios noted that he had been dealing with local issues south of Mexico City for so long that it has become his focus. He now works south of Mexico City, which is technically in Central, not North America. Coming from this perspective, it is very difficult to think of North America as a single, homogeneous region. Mexico is quite different from many parts of North America, and southern Mexico is different from northern Mexico. “There is the big promise of NAFTA,” he said, “but I’m not too optimistic about it.” He suggested that the question be changed to bring a science agenda down to the local level, something that will require very different institutions depending on the region. He asked how one constructs a concept of welfare—should it be emergent? Mexican culture has a tradition of building up institutions so that communities and people will flourish. This also has to do with incentive systems, for example that tries to value ecosystems. Barrios suggested that more research needs to be conducted on multi-criterion systems. As for methods and models, he said that finding or developing THE model is impossible—several models will have to be constructed, depending on whether sustainability is seen as a crisis science or a restoration science. Heterogeneity will provide different answers.
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- Pamela Matson said that the questions are reasonable and valid, but agreed they should be asked from the bias one is working in. “I think the iteration between policy and research is interesting—how they push each other. I see us pushing into areas where we do not have the policy, and vice versa.” Matson said that raised the question of how narrow and broad policies are and how they compete with each other. Many policies are driven by human health concerns, and present huge challenges, such as issues of water quality or ecosystems. Once the whole picture is taken into consideration—that ecosystems need water in order to supply other systems—it becomes an even larger challenge. “There’s a whole research effort needed, along with the question of how

individual policies aimed at small pieces of research fit or do not fit the puzzle.”

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- Ian Burton said he had just become aware that reports from the National Academy of Science have changed the terminology from *Sustainable Science* to *Science and Technology for Sustainable Development*. He found the shift worrisome as it could “signal a collapse back to a less integrated vision of what we are trying to do. I’m discouraged because we haven’t grasped it and forwarded it, as we should. I would like to strongly encourage the more integrated view.” Many felt this would happen from the grass roots up, but if it does, is there a role for global thinking? Burton said that the grassroots must be encouraged while putting the global architecture in place to facilitate this, either through the WSSD or an intergovernmental panel on environment and human health. He suggested that IPCC had been a successful model. “Type 2” initiatives—those that are less than global, but still holistic and crosscutting—are already underway, for example, the initiative on North American air quality. He questioned, however, how these mosaics would add up to something on the global level. One of the questions asked how the initiative would differ if it was needs based, and Burton replied that it would be “quite different.” He said he would like to see the core questions rephrased, not to come up with a wish list of needs, but to consider those issues that scientists have a reasonable possibility of doing something about. “What happens in North America has a huge importance and impact on the world,” argued Burton, adding that it is short sighted to use only North American criteria. “We need to think globally, and consider what the world needs,” he said. The differences between co-operation and competition have to be considered, and work undertaken on adaptive capacity.
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- Robert Kates said that of all the meetings held thus far, this one had been the best at incorporating a good mix of policy and science—a co-production of knowledge. He said he was initially skeptical of the design of the conference, but given the good introductory sessions, it worked out favourably. Kates noted that only one of the priorities for knowledge and needs—ecosystem restoration—was discussed at length. This session did not address definitions of need. All the core questions were discussed. However, the set of technology-based core questions—such as the feasibility of creating renewable energy supplies with the same conversion efficiency as non-renewables—are difficult to answer without technological expertise. A number of corporate representatives were invited to the meeting, but none came. Kane said he had also heard some caution about a focus on place-based settings and solutions, and learned that society is a victim of overcapacity. Finally, there are the financial questions—how one supports “the large and the long” to carry through to the next two generations. This concept is alien to most budgets, so time and again short-term views have precedence. The WSSD is a prime example, said Kane. Ten years from now that will be a footnote on the way station.”
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- Lisa [Harrington] had four points to make:

Comment: Note to Environment Canada: I only wrote down the name Lisa, and assume it was Lisa Harrington. There was another Lisa present who left before the final round. Perhaps Paul would remember if this is the right Lisa.

- Scale matters, but so do place and connections.
- There are political barriers to the application of policies in support of sustainability. These are often short-term self-interest barriers.
- Technological application is dependent upon perceived need, and cost and benefits.
- Both ecosystems and social systems may be more resilient than expected. Harrington said she based this last comment on two years of research around Mt. St. Helen.
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- William Glanville focused on what he thought were the most important concerns, beginning with emerging models, integrating lessons learned. The next two are numbers six and seven, which provide the bridge between science and technology and a policy agenda—the “so what.” There are multiple examples of co-operation, both cross disciplinary and cross regional. Going beyond this science and technology agenda, Glanville noted that the concerns of the Brundtland Commission are intergenerational. He strongly recommended that science and technology be used to inform education, calling it a “fundamental responsibility.” On application, a benefit would be contributing to the establishment of an innovation agenda that starts with ideas, and ends with implementation. A ten-year assessment is needed at the minimum. Glanville urged that targets be established.
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- Denis Demars discussed the problems inherent in agriculture in Canada, including soil erosion, water conservation, contamination, and the loss of biodiversity. He noted that 20 years ago scientists were performing more curiosity-driven research, while the emphasis today is on an alignment between research priorities and policies. More studies need to take place on the interaction between crops and the environment, looking at crop and plant physiology, how crops relate to drought, modelling, prediction of disease and insects, and alternatives to chemicals. However, in order to ensure the sustainability of agriculture, help is needed on the funding side. “If we want research we need the resources,” he concluded.
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- Richard Getzinger also remarked that he had enjoyed the workshop, and described the projects he undertakes in various parts of the world on watersheds. “These are large and complex issues—we work with local partners and NGOs and try to mitigate the human impact on the environment. We are very needs based, pragmatic.” He said that what is needed most is a framework and a “big picture view” of what to look at. “We look to the sustainability science and thru WSSD. Although we don’t work on this continent, your discussion is good,” he said. Human capacity building picture is very important—Getzinger commented that many parts of the world have no capacity to deal with urgent issues. Training and science education needs to be more focussed. There is a huge need for conflict resolution as well— Getzinger said, “In many parts of the world even if we knew what to do we couldn’t go in to do it.”
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- Commenting that he preferred “sustainable development” to “sustainability”, Robert Slater had three suggestions for the core science questions:
- First, Slater said he would attach a high importance to sharing knowledge and how to disseminate it, and make that happen. He suggested taking two or three “doable” items such as mercury as an ecological contaminant and human health issue. “I would find a way of doing one scientific assessment the world could use. Find one or two or three of those things to show we were on course to share knowledge. I prefer what we can do to obstacles.”
- There are special places that North Americans might pay attention to, and these should be used. Slater said he was “a big fan of the Arctic.” It demonstrates a fragile ecosystem, the need of Indigenous peoples, and presents a global manifestation of human activity. Slater also proposed looking at other things that North Americans could support—the Great Plains (the big bread basket of the world), the Great Waters (the Great Lakes), the Great Rivers, and the Great Forests. All are globally significant places.
- It is a challenge to keep an issue in the public domain for 50 years, especially when one considers the number of changes in governments, university presidencies, etc. Slater related that during the 17 years he was responsible for acid rain in Canada, he lived through huge changes in administration. One way to keep an issue alive is to make it the “people’s agenda.” That way the new politician or administrator already had a job to do when he or she first arrives at their desk. There was the notion that once an office was assumed, there was a duty to see the task through. Slater equated it with having a larger vision.
- In reviewing the core questions, Slater said that all seven “are on the money.” From the point of view of a monarch butterfly, it is reasonable to assume that a North American ecosystem is its ecosystem. It makes sense to look at North America in that context. There is some capacity to get the North American slice in front of ministers on a periodic basis, but there has to be a way of popularizing science. “For capacity building, we have the opportunity to bring people together to share information,” he concluded. “We are building capacity in all three countries.” Slater suggested that the group take advantage of CEC.
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- Philippe Crabbé said that he finds where science informs, it speaks to policy, as in the IPCC model. Policy must be precautionary—public policy is not articulated out of economics, it has to be evidence based, not certainty based. Resources have to be proportional to the severity of the problem. Crabbé said that the main reason to ratify the Kyoto Protocol is because it will provide an opportunity to set up the institutions that will be required to manage the issue in the future. Science has an important contribution to make developing good models in interdisciplinary research. An academic reward system exists, but not for interdisciplinary research. This will have to change if barriers are to be broken down and bridges built. Policy makers have to remember that people are not calculating machines, only worried about economics. They have a sense of responsibility,

social allegiances, and need a sense of meaning in their lives. There are “dividual”, not only individual value systems, each with their own hierarchy of concerns.

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- Noting that he approaches this issue from the perspective of an urban and regional planner, Keith Pezzoli said his preference is for question #7. The challenge is to build the context to bridge the gaps inherent in sustainability science, including unique challenges in the U.S.-Mexico collaboration needed in the south. Pezzoli has been involved in collaborating science and research efforts in watershed-based approaches to toxins, environmental management systems, land-use, and integrated regional planning. They first built an asset map, and are working to provide a Web-based research portal. The end result will be a bio-geophysical canvas that advances the knowledge of visually-based information. “It’s a science-based interesting story,” said Pezzoli, “but beneath it is a menu for the data and technology behind it.”
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- John Stone observed that this second meeting he had attended in the last two months on science and sustainability was different, as more people attending this one came from a policy background. Some people involved in the issue feel that Rio promises have not been fulfilled, a claim that will come under a microscope at Johannesburg. As North Americans will be under that same microscope, Stone said, “We owe it to ourselves to show some leadership, and we haven’t done that—we’ve talked a lot. We have no credibility. We can have meetings, but for the developed world to help we need the credibility.” Secondly, Stone said he believes there is still a lot of fundamental science that needs to be done. In order to make change, North Americans will have to focus effort on a limited number of pragmatic issues, taking advantage of the richness of the science and technology already available. “We have the science and technology to enable our three countries to meet our Kyoto Protocols. We have to ensure we don’t have a repeat of Walkerton, and have to get our head around biodiversity and ecosystem function.” Stone suggested that a way forward would be to focus on vulnerable populations in North America, such as the poor and the Inuit. “Here is a group of people who have contributed little to the climate change problem, but will have the most problems with it.” Next, he said, scientists need to come to grips with urban development, which drive many of the research questions. If megacities are allowed to increase, the earth will lose its social cohesion and strangle, damaging the possibility of tackling some of these issues. Finally, industries such as natural resource management, forest services, etc. have a record of spoiling the environment. “If WSSD is there to focus our minds, we owe it to ourselves and our countries to clean up our own act first.”
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- Omar Massera said that the importance of the North American perspective should be noted, along with differences. Mexico needs to think about a science and technology agenda and sustainability—it lacks the critical mass to explore basic issues. Next, there is a need to emphasize the positive with new alternatives and approaches, and push the development of

university co-operation. There is especially a need to explore new urban environments and look beyond and think about different arrangements of living conditions. Preventative measures, not remedial ones should be emphasised. Finally, Massera said there is a need to focus on natural resources management and develop new assessment methodologies that integrate traditional knowledge.

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- Twig Johnson argued that the three countries are uniquely placed—each one has a democracy with inherent freedoms—to use market-based incentives for ecological reform, and finance the kind of research needed through market mechanisms. Together, they have a great deal of experience in creating dialogues between sectors—those in economics and those in the environment—to move an agenda forward. Johnson said it is important to have a mechanism for the three countries, like CEC. As an example, he noted that Mexico has more experience dealing with ENGOs, and can contribute lessons learned, both positive and negative. North Americans have a great capacity organizing, and dealing with the long-term sustainability issues, but should concentrate on the longer term. Finally, “There is a huge concentration of capacity, and we need to think about how to use that better,” he suggested. North Americans could reach out internationally to help with capacity building by funding more graduate studies. Johnson noted that most local governance structures do not have the tool kits to identify point source pollution, an area for both research and application.
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- Stuart Smith thanked his co-chair, and commented on the very interesting discussion. He made the following points:
 - Science and technology for sustainable development. Science and technology not only need to focus on certain areas, they need to integrate around that focus, both between countries and between disciplines. The way to do that is to institutionalize it in some way. There are also capacity-building issues, something that is particularly true in Mexico, but also in Canada where budget cuts over the past two decades have decimated its capacity.
 - Some of the issues of sustainable development require more science and technology, while others are prevented from accessing what’s there by political issues, processes, or governance issues. Science and technology has a role to play, but not in every instance.
 - Science and technology must not only contribute to the understanding of a problem, but also to its solutions.
 - Science and technology has a role to play in a place-based or regional settings. There is a tremendous role in focusing on regional issues, which in fact might be a sub-category of focus. Some regions are more worthy of general study as they are of interest to many parties.
 - A subsidiary point is the educational role science can play.
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- Commenting that both America and Africa are funnel shaped, Exequiel Ezcurra described

how North America tapers to the equator, and how “deep Mexico” is an area of high biological diversity. “This is both a blessing and a curse,” he said. “The blessing is the richness of species—it’s the cradle of 50% of what the world eats. On the other hand, it’s very fragile.” Ezcurra noted that there are more species of ants in one tree in this area than there are in the whole European continent. Correlated with this is the large number of languages spoken; this is an area of high cultural and biological richness, but it has a problem not yet analysed. If one cuts a mahogany tree down in a tropical forest, hundreds of useless trees will have to be cut down in order to reach it, and there are 400 species of trees in one hectare. When nets are thrown to cast for shrimp, many useless (to the fisherman) species are thrown away. “It’s incredibly difficult,” he said. “We have this debate inside Mexico. The industrialized north is subsidizing the more depressed south, but we haven’t been able to make the country understand the importance of the ecological services provided by this diversity.” Mexico is a sanctuary for incredible biological richness, so there are biological and cultural restrictions to moving to large scale, homogeneous production. “This discussion is very important for North America and the world,” concluded Ezcurra. Dowdeswell pointed out that one could make the inverted case for the Arctic, regarding fragility and social systems that don’t translate very well. Ezcurra said that the history of civilization has been the history of humans exporting one ecosystem. Areas that have not been adaptive to that have suffered.

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- John ApSimon thanked the chairs, all participants, and Paul Samson for their contributions. Speaking from a 30-year perspective as an educator, he said that this provides “a real opportunity” to do something for new generations—the idea of trying to effect a cultural change in the educational process. He suggested participants go an elementary school science fair to see first hand the multi-disciplinary approach to problem solving embedded in elementary education, an approach that has yet to reach the university level. ApSimon said that during his tenure at Carleton University, he had students come to him wanting to work on a multi-disciplinary doctorate. However, most faculties were not set up to support this. He suggested that this could be an opportunity to influence agencies, and support trans-disciplinary students in sustainability studies. “Let’s look for projects we can deliver so that 50 years down the road we can deal with this,” he said.
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- Bob Correll agreed with an earlier comment that WSSD is just a way station. However, the drivers of the agenda need to be more clearly articulated. Correll suggested that participants should be concerned about a venue, a way of furthering the dialogue for the longer term. In the short term, leadership will be important. In the WSSD context, a commitment will be needed to establish some Type 2 studies, and implement them on a trans-national basis. This is a departure from Rio, which concentrated only on global issues.
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- Elizabeth Dowdeswell remarked that she had come up with four concepts that were identical to those of Stuart Smith. Much had been heard about place-based research and a regional focus. Much more explicit was the issue of maturity, and how it impacts not only on the response mechanisms, but also on basic science and technology. Dowdeswell said she would like to think further on this, in order to focus scarce resources. Next is the issue of using research and science for identification of a variety of solutions. There had been discussion the previous day about tools and finding methodologies to take the science, interpret it, and use it. Integration was also seen as important. Speaking as one who “hops around jobs every few years,” Dowdeswell said the spin should not just be about integrating across discipline, but integrating the science and the policy. Individual and institutional attitudinal and behavioural change should also be a priority, and may include creating new models of governance that allow for greater efficacy. “I don’t think global treaties are the be all and end all for dealing with environmental problems,” she said, adding that she had enjoyed the opportunity to be at the table.
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- Dowdeswell thanked Environment Canada, and in particular Paul Samson, as well as “the two Bobs”—Correll and Kates. Speaking from a Canadian perspective, she noted that there are no ongoing institutional mechanisms like the U.S. National Academy of Science to provide an ongoing voice, and would welcome Shantora’s initiation to use the CEC. Dowdeswell said she found the level of side conversations to be exciting, and hoped the tri-dimensional understanding would continue on an issue-specific basis.
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- Kates urged participants to join the network on sustainability science, and see firsthand how this experiment in collaborative work moves forward. He expressed thanks on behalf of everyone who was a guest of Environment Canada.